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Enhancing Underwater Gray Scale Images Using a Hybrid Approach of Filtering and Stretching Technique

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Abstract— *Underwater image processing has received more attention from last few decades, underwater image quality is affected by several factors such as light attenuation, scattering, refraction, turbidity etc. because of this effect non uniform illumination, low contrast and blurring effect will arise in underwater images. The algorithm used in this paper uses both stretching and filtering technique to enhance the quality of underwater images and has been succeeded in correcting non uniform illumination, reduces noise and enhancing contrast. Here it uses histogram equalization and contrast stretching for enhancing the contrast, it uses a Homomorphic filter for uniform illumination and reduce Gaussian blur, wavelets are used for reducing Gaussian and salt and pepper noises, Anisotropic filtering is used for enhancing foreground(edges) and acts as low pass filter for background.*

Simulation is carried out using MATLAB (R2010b), visual quality and PSNR shows the improvement in quality of underwater images.

Keywords—Filtering, Homomorphic filter, Stretching, Underwater image enhancement, Wavelet denoising,

I. INTRODUCTION

Underwater vehicles are used to survey the ocean floor, much often with acoustic sensors for their capability of remote sensing. Optical sensors have been introduced into these vehicles and the use of video is well integrated by the underwater community for short range operations. However, these vehicles are usually remotely operated by human operators: the automated processing and analysis of video data is only emerging and first suffers from a poor quality of the images due to specific propagation properties of the light in the water. So, it is necessary to pre-process those images before using usual image processing methods. These collected images are used to provide information about water species, underwater archaeology, marine pipelining, underwater mining, underwater building (underwater tunnels), shipping (to identify ice rocks) etc. Underwater perception is an experimental field for researchers and marine engineers. The visual quality of underwater images is usually very poor due to several factors, such as light attenuation, scattering, refraction, non-uniform lighting, blurring, and noise etc. Capturing of photograph from high sensitive camera is still affected by visibility inside water, which depends upon the amount of light reaching at that depth of water (that depend on the salinity of water, reflection and scattering of light). Thus, these factors of visibility can be considered as transmission loss of light or as attenuation of light [2].

1.1 Light Attenuation: It is defined as the reduction in intensity of the light beam with respect to distance travelled through a transmission medium [6]

Table 1. describes the details of colour absorption at various depth of water. Light colour absorption also affected by quality of water. It is also mentioned that the colour absorption is also depends on the wavelengths of different colours [7].

Table 1. Colour absorption and average wavelength in depth of water

Colour	Average Wavelength	Colour Absorption at Approximate Depth
Infra-Red	800nm	3m
Red	685nm	5m
Orange	600nm	20m
Ultra-Violet	300nm	25m
Yellow	575nm	50m
Violet	400nm	100m
Green	525nm	110m
Blue	475nm	275m

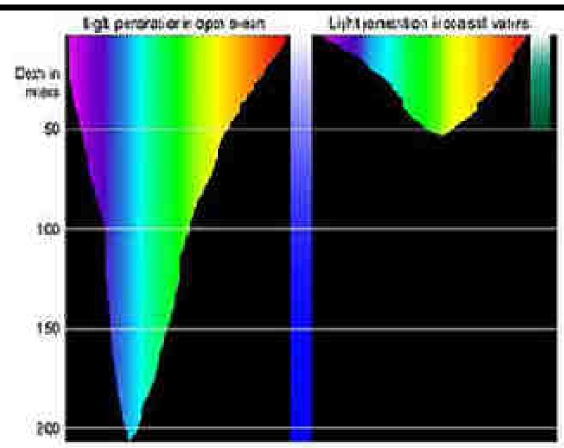

Fig. 1 Light penetration of different colours in clear (Open Ocean) and dirty water (coastal water).

1.2 Scattering**:** It is the phenomenon of light diverting back when passes through a medium. Strength of scattering measured by loss of energy in light signals as it passes through a medium. Scattering also occurs in air but it cause greater concern in water as most of the light beams are diverted due to molecules of water itself and due to dissolved organics. Scattering is of two type forward and backward. Forward scattering cause blur the image features while backscattering cause reduction in contrast of images.

1.3 Refraction**:** This phenomenon also causes problems in underwater imaging. The light waves are turned when they traverse from mediums of different density. In underwater photography the refraction occurs at the interface between the air and the water. Output of refraction is object appears larger than its original size. If objects are closer to camera than they seems to be more nearer than actual position of those in water.

In Section2, proposed approach and detailed algorithm of each technique used is described in detail. In Section 3 results of the proposed method and performance parameters calculated are discussed, followed by conclusion and future scope in Section 4.

II. PROPOSED APPROACH FOR UNDERWATER IMAGE ENHANCEMENT

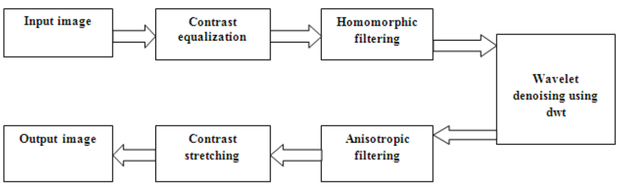

Fig. 2 Proposed approach for Underwater Image Enhancement process

2.1 Detailed Algorithm of the Techniques used for Underwater Image Enhancement

2.1.1: Contrast Stretching (Normalization)

It is improving the contrast in an image by enlarging therange of intensity values. The linear scaling function is applied to each pixel value as follows:

$$Eo = (Ei - A) \times (B - A) / (D - A) + C \quad ......(1)$$

Where

- E_i is the considered pixel value;
- E_o is the normalized pixel value;
- A is the current lowest pixel value.
- B is the maximum value of the required range;
- C is the minimum value of the required range;
- D is the current highest pixel value.

2.1.2: Homomorphic Filtering:

Homomorphic filter is to stabilize the brightness and to increases contrast of poor illuminated image. It also eliminates multiplicative noise that occurs due to presence of noise signals in significant signals. As filtering techniques work in either spatial domain or frequency domain same way this filtering technique works in frequency domain.

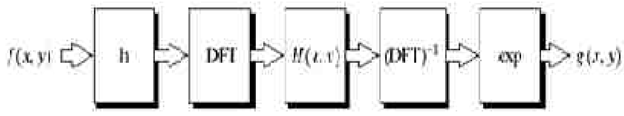

Fig 3 Step by step algorithm of Homomorphic filter

Gaussian high pass filter is used and it is given by,

$$H(u,v) = 1 - [\exp(-((u^2 + v^2)/(2 * \sigma^2)))] \quad ....(2)$$

2.1.3: Wavelet De-noising:

it is non-linear thresholding technique with a wavelet coefficient. In this technique coefficient compare with threshold and if it is smaller than threshold then it set to zero if not then it is modified. Swap the tiny noisy coefficients by zero and inverse wavelet transform result in crucial signal characteristics with very less noise[8][9].

$$(p) = \begin{cases} 0, & p < 0 \\ p, & otherwise \end{cases} \quad .... (3)$$

2.1.4: Anisotropic filtering:

This filter removes or attenuates unwanted artifacts and remaining noise. The anisotropic diffusion algorithm is used to reduce noise and prepare the segmentation step. It allows to smooth image in homogeneous areas but it preserves and even enhances the edges in the image. We follow the algorithm proposed by Perona and Malik [5].

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This algorithm is automatic so it uses constant parameters selected manually.

$\nabla_N (I_{i,j}) = I_{i-1,j} - I_{i,j}$, $C_{Ni,j} = g(|\nabla_N I_{i,j}|)$ ..(4)

$\nabla_S (I_{i,j}) = I_{i+1,j} - I_{i,j}$, $C_{Ni,j} = g(|\nabla_N I_{i,j}|)$ ..(5)

$\nabla_E (I_{i,j}) = I_{i,j+1} - I_{i,j}$, $C_{Ni,j} = g(|\nabla_N I_{i,j}|)$ ..(6)

$\nabla_W (I_{i,j}) = I_{i,j-1} - I_{i,j}$, $C_{Ni,j} = g(|\nabla_N I_{i,j}|)$ ..(7)

Modification of the pixel value

$I_{i,j} = I_{i,j} + A[C_N \, \nabla_N I + C_S \, \nabla_S I + C_E \, \nabla_E I + C_W \, \nabla_W I]_{i,j}$

with $0 < A < 1/4$ ……..(8)

2.2 MATLAB SIMULINKIMPLEMENTATION

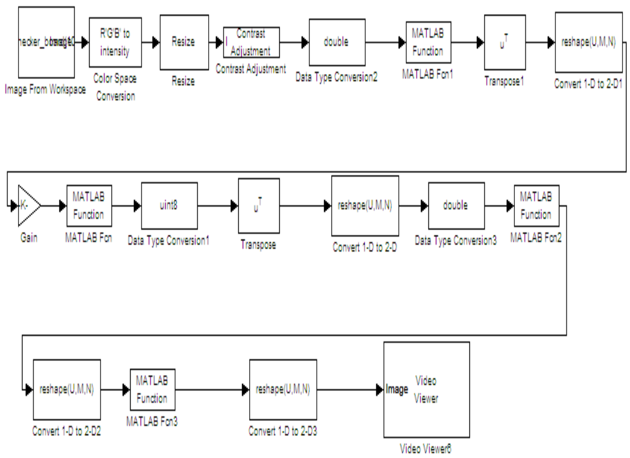

Fig. 4 MATLAB Simulink model

In the above simulink model, MATLAB Fcn1 = Homomorphic filtering function, MATLAB Fcn = Wavelet denoising function, MATLAB Fcn2 = Anisotropic filtering function, MATLAB Fcn3 = Contrast stretching function all these functions are written MATLAB and stored in working directory.

III. RESULT

3.1: Parameters Used for Analysis

3.1.1: Mean Square Error (MSE): It is defined as the ratio of square of difference between the input image pixel value and output image pixel value to the size of image (row*column).

3.1.2: Peak Signal to Noise ratio (PSNR): It is defined as the logarithmic of the value of ratio of size of the image and the MSE of image.

3.1.3:Visual Quality:It is the subjective method of evaluating the quality of the image by looking the original and enhanced images

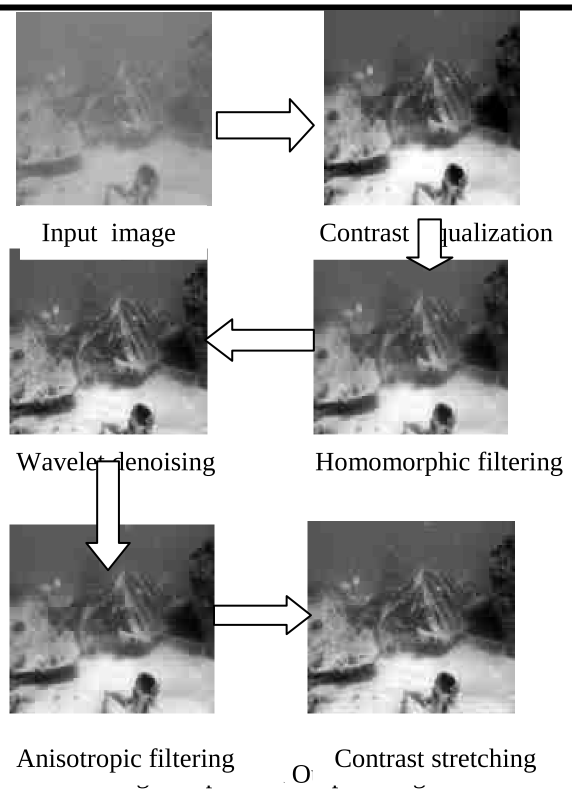

Fig. 5 Input and Output images

Table 2 MSE and PSNR of output image in three different techniques

Parameters	Stretching technique	Filtering technique	Proposed technique
MSE	1246	734	645
PSNR	17.1756	19.4738	20.0352

IV. CONCLUSION

Underwater image enhancement is a tricky work and it is one of the research stream in Digital signal processing. Even though having high definition cameras to capture underwater images it is still a challenging problem for researchers. In this paper it has been used the various stretching and filtering technique for enhancing underwater images and the results (performance parameter) shows the improvement in quality of underwater images. Further it can also be used to enhance underwater colour images and also still more adjustments can be done for this work to enhance still more efficiently.

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